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AN AUTOMATIC PHOTOELECTRIC TRIGGERING MECHANISM FOR A DATA-RECORDING CAMERA

by

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ABSTRACT

An automatic photoelectric triggering mechanism was designed and developed for a data-recording 35-mm pulse-operated camera recording information about individual pieces of lumber as they are produced in sawmills. This triggering mechanism does not physically contact boards moving on the conveyor chains and will operate for any random spacing of boards.

Photographic recording of data is particularly useful where numerous repetitions of data or information must be documented over long periods of time. Such a technique is well suited for recording lumber production information needed in sawmills. Detailed information about each piece of lumber moving on conveyer chains (fig. 1) is easily, accurately, and permanently recorded.[2/]

Development of a satisfactory photographic technique for application in sawmills had its share of technical problems. Many of these problems, e.g., the type of camera, correct exposure for a given film and lighting condition, best film types for detail resolution, were

Figure 1.--*Photo record of lumber on conveyor chain in a sawmill. Board number, grade, length, width, and thickness are permanently and accurately recorded.*

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2/ Harvey H. Smith. Photographic data recording in mill studies. Unpublished Pacific Southwest progress report, 10 pp., illus. 1964.

solved by trial and error; others required further equipment development to make the whole system more compatible for use in sawmills and to reduce the probability of equipment failure.

One difficulty encountered in early models of the system was the fragility of the triggering mechanism used to trip the pulse-operated camera and other auxiliary equipment. Triggering was accomplished by a microswitch mounted on the conveyor chain (green chain) and depressed by boards moving on the chain. As the repetitious physical impact of the boards on the switch made it vulnerable to breakage, it was necessary to install an additional manually operated pushbutton switch parallel with the microswitch. This switch permitted triggering the photographic data recording system on command in case of microswitch failure. The switch was also used whenever spacing between boards was not sufficient to permit the microswitch to reset after each photograph. A triggering mechanism of this type required the full attention of one man.

Because of the fragile nature of this triggering mechanism and the attention it required for proper operation, a different type of mechanism for tripping the camera was designed and developed which did not in any way make physical contact with boards moving on the green chain and was completely automatic.

GENERAL DESCRIPTION

Basically, the new triggering mechanism consists of a light beam and photoelectric relay and a pulse generator. These are electrically connected to the pulse-operated camera, strobe light, and power supply through a junction box (diagramed in fig. 2A). In operation (fig. 3), the electrical pulse needed to activate the camera is first initiated with the interception of the light beam directed on the photoelectric relay. With the closing of the photoelectric relay, the pulse generator is then activated to produce the necessary electrical pulse for the camera.

PHOTOELECTRIC RELAY AND LIGHT BEAM

The photoelectric relay and light beam can be any one of a number commercially available. We used a Sigma Series 8 PL 2 (fig. 4) operating on 110 VAC, 60 cycles.[3/] The photocell in this unit is a cadmium sulfide photoconductive cell which activates an electromagnetic relay. A light level of 5 footcandles or more is needed to operate the photoelectric relay; the companion light source produces this level at a maximum height of 12 feet.

Trials at lumber mills demonstrated that best results were obtained when the photoelectric relay was mounted at the green-chain level and the light source mounted 6 to 8 feet above and directed down on the photocell. Because the photocell was too sensitive to stray light, a blackened metal cylindrical shield with a 1/2-inch hole was used to cover the metal lens housing of the photoelectric relay (see fig. 4). Mounting the photoelectric relay on the outer edge of the green-chain floor with a 1/2-inch clearance between the top of the shield and the bottom of the moving boards virtually eliminated premature triggering.

The photoelectric relay was so wired that all contacts were normally closed (i.e., no light on the photocell). Output leads from the photoelectric relay to pins A, B, C, and D were permanently wired together at the 110 VAC plug of the photoelectric relay (see fig. 2A). Because of this it was necessary to observe polarity

[3/] Mention of products by name does not represent endorsement by the U.S. Department of Agriculture.

in wiring the pulse generator (see fig. 2A and table 1).

PULSE GENERATOR

In designing the pulse generator, a number of physical and functional features were incorporated. As compactness was important, the complete unit was designed to fit in a stainless steel box measuring 8 by 8 by 6 inches (see fig. 5). Internal wiring was number coded for easy reassembly, and external electrical connections were color coded, matched, and labeled to prevent errors in connecting auxiliary equipment. A frame counter was installed to register the number of exposures made by the camera.

The pulse generator consists of two major components and one major circuit (see fig. 3). These are a time delay relay (TDR) which is a slow-action relay, a pulse-shaping timer relay, and the uni-junction transistor (UJT) circuit. The timer relay is activated by either the TDR or the UJT circuit (see figs. 2A, 2B and 2C), each of which becomes operative only under certain green-chain conditions.

Time Delay Relay

The time delay relay (TDR) (see figs. 2A and 2B) becomes operative each time a "make and break" situation develops at the photocell. This condition occurs whenever there is a series of spaced boards on the green chain. The passage of each board between the light source and the photocell closes the photoelectric relay. When this happens, the TDR is activated. There is a preset delay between the closing of photoelectric relay and the subsequent operation (opening) of the built-in single-pole double-throw (SPDT) relay (normally closed) in the time delay relay. This delay allows a pulse current (110 VAC) to activate the timer relay (see fig. 2A). Thereafter, as long as the photoelectric relay remains closed (no-light condition) the time delay relay will remain open; it resets instantaneously upon the opening of the photoelectric relay with the passage of the board.

The time delay relay used in the present triggering mechanism was an Industrial Timer Series TRP-5 plug-in, adjustable delay relay operating on 110 VAC, 60 cycles (figs. 2B and 5). The delay time of this particular unit is adjustable from 0.1 to 5 seconds. A 0.1-second delay was found adequate for activating the timer relay. Wiring details of the time delay relay are shown in figures 2A and 2B and table 1.

Uni-junction Transistor Circuit

The uni-junction transistor (UJT) circuit is a timing circuit for triggering the camera under certain green-chain conditions. If all boards to be recorded are spaced on the green chain to allow a "make and break" situation at the photocell, only a time delay relay electrically connected to a timer relay would be necessary to trigger the camera and auxiliary equipment. In practice, however, often a series of boards is unspaced, and under these conditions, only the lead boards would be recorded.

To provide for an unspaced series of boards on the green chain, a separate solid state circuit was designed which would generate at regular intervals the 110 VAC pulse necessary to activate the timer relay (see fig. 2A). This circuit becomes operative only after the TDR pulse expires and the latter relay remains open for a predetermined length of time activated by either an exceptionally wide board or an unspaced series of boards passing over the photocell. As long as the TDR remains open, the UJT circuit will continue to generate at regular intervals the electrical pulse necessary to activate the timer relay.

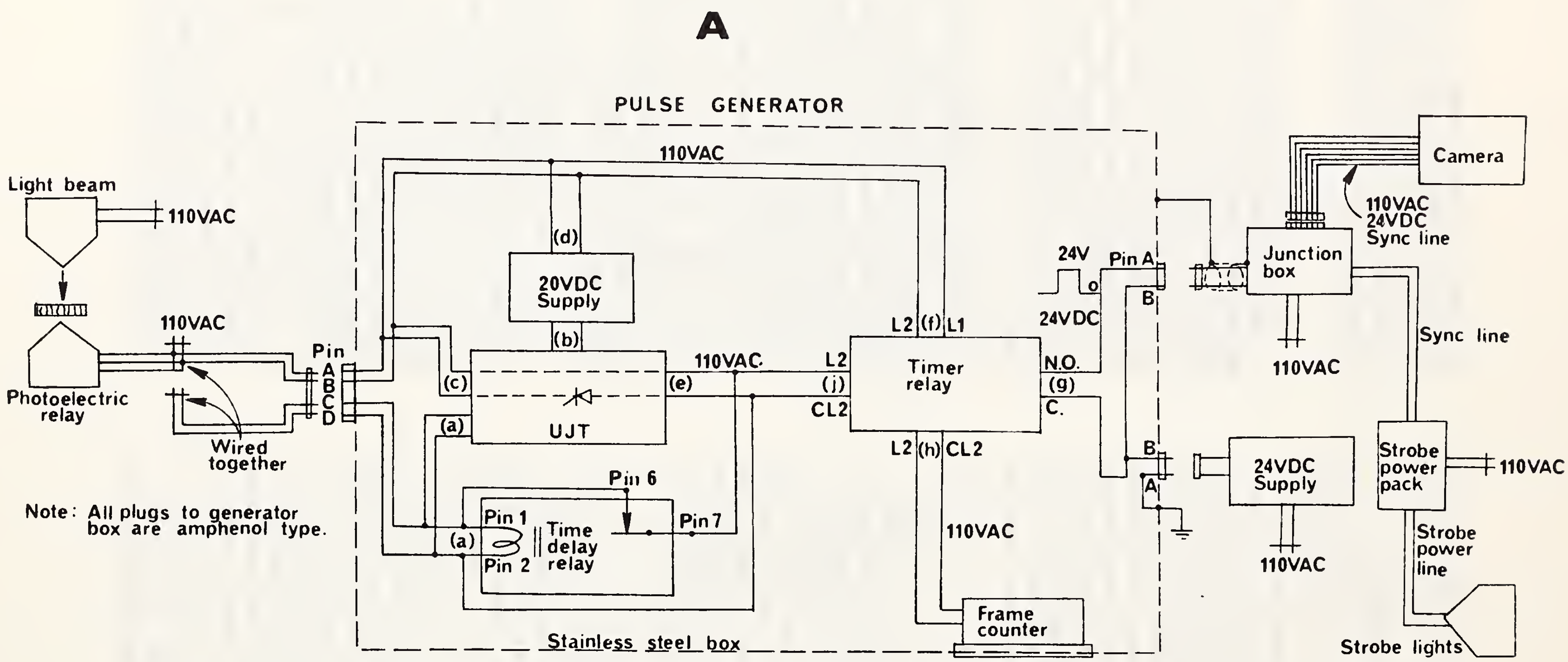


Figure 2A.--*Diagrammetric layout of a complete photographic data recording system with component details for the triggering mechanism.*

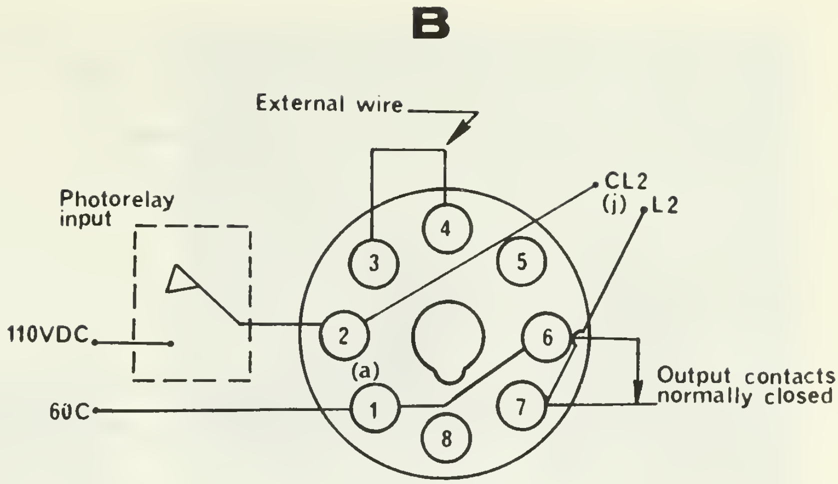


Figure 2B.--*Wiring details of the base of the time delay relay.*

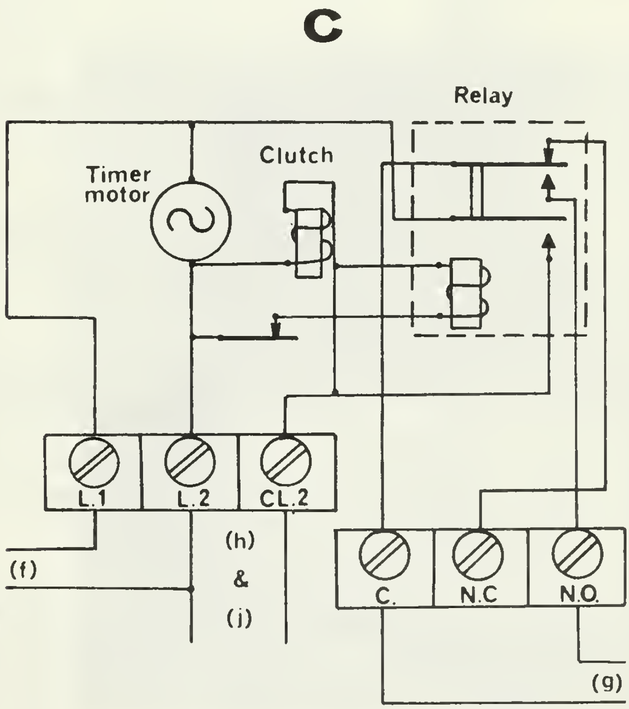


Figure 2C.--*Wiring details of the timer relay.*

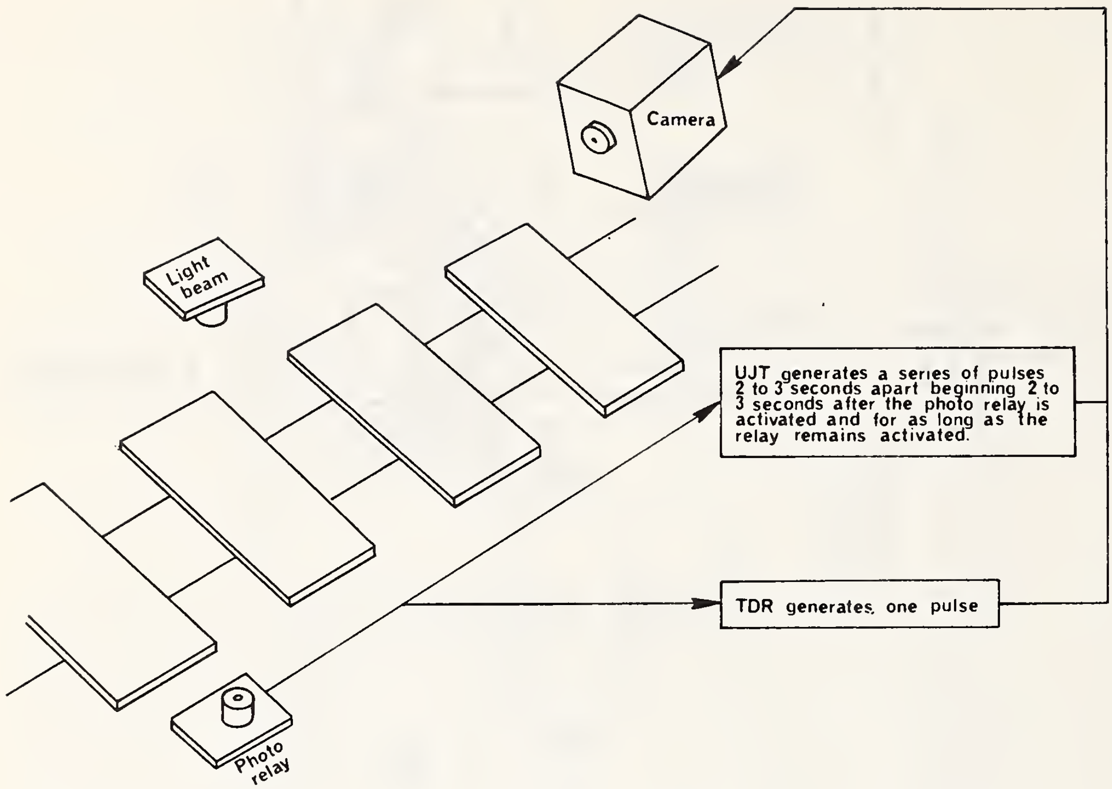


Figure 3.--*Block diagram of the pulse generation path in the photographic data recording system.*

Table 1.--Wiring chart for pulse generator: location and component connections

Location	Component connections
(a)	UJT - see figs. 2A and 6; TDR - pin 1 and 2, see figs. 2A and 2B
(b)	UJT - see figs. 2 and 6; 20 VDC supply - see fig. 7
(c)	UJT - see figs. 2 and 6
(d)	20 VDC supply - see figs. 2 and 7
(e)	UJT - see figs. 2 and 6
(f)[1/]	Timer relay, L1 and L2 - see figs. 2A and 2C
(g)	Timer relay, N.O. and C. - see figs. 2A, 2C, and 8
(h)	Timer relay, L2 and CL2 - see figs. 2A and 2C
(j)[1/]	Timer relay, L2 and CL2 - see figs. 2A, 2B, and 2C

[1/] Since leads to (f) and (j) are permanently wired together at the photoelectric relay plug, polarity must be observed.

Figure 4.--*Photoelectric relay (left) and light beam (right) used in automatic triggering mechanism.*

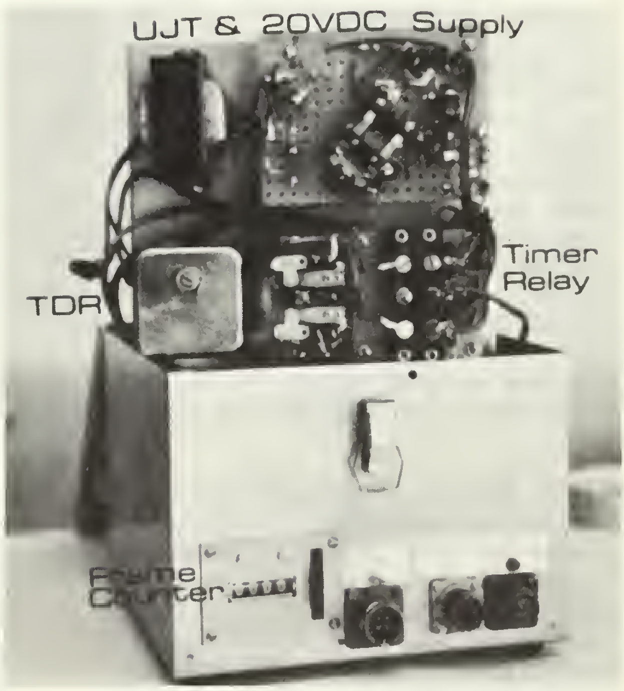


Figure 5.--*Placement of components used in the pulse generator.*

Details of the UJT circuit and its power supply are presented in figures 6 and 7. The placement of the components in the circuit is shown in figure 5.

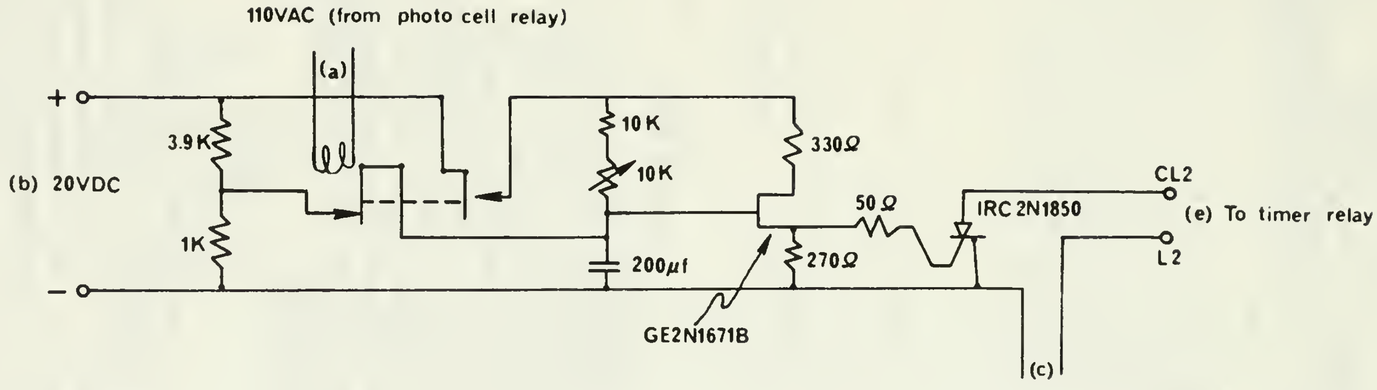
In actual operation, the UJT circuit can be described as follows (see fig. 6): The closure of the photoelectric relay results in the closing of the relay in the UJT circuit. When this occurs, the 200 μf capacitor begins to take on a charge from the 20 VDC supply. The rate at which the capacitor is charged is controlled by the 10 K variable resistor incorporated in the circuit. The capacitor discharges suddenly through the 2N1671B uni-junction transistor when the critical or "avalanching" voltage of the transistor (approximately 0.4 of the supply voltage or 0.4 x 20 = 8 volts) is reached during the charging of the capacitor. The transistor then conducts, activating the 2N1850 silicon controlled rectifier. This momentarily applies 110 VAC to the timer relay. The duration of the 110 VAC pulse to the timer relay is essentially the discharge time of the capacitor through the transistor (approximately 75 milliseconds) and corresponds roughly to the time it takes the transistor voltage to drop to approximately 4 volts. Once discharged, the capacitor is again recharged; and upon reaching the critical voltage of the transistor, it again discharges. This cycle will continue as long as the photoelectric relay remains closed and the TDR is open.

The UJT circuit cannot operate as long as the photoelectric relay is closed for less time than it takes to charge the capacitor. The charging time selected depends on a number of factors closely tied to the actual study (such as green-chain speed, board size, and working room available) and to limitations of auxiliary equipment (such as lens coverage and recycling time of the strobe power pack). If the charging time selected is not exceeded by the close time of the photoelectric relay, the TDR pulse will be the only pulse which will operate the timer relay; if the charging time is exceeded the UJT circuit will be activated. Tests with the photoelectric triggering mechanism indicate that a 2- to 3-second charge time is adequate for coverage of most green-chain conditions.

Timer Relay

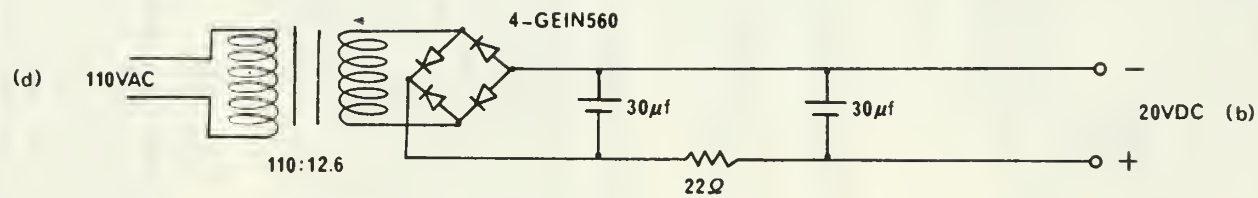
The momentary pulse generated by either the TDR or UJT circuit is not of proper duration and voltage to directly operate the data recorder (fig. 2A). The timer relay accepts the TDR or UJT pulse and generates an electrical pulse output sufficient to operate the relays, shutter, and takeup motor in the camera for a single frame. In the present photographic system, a 35- to 50-millisecond pulse, 24 VDC, is needed. This is supplied by a 24-VDC supply, which is external to the pulse generator but wired to the timer relay through amphenol plugs (see figs. 2A and 5). Details of the 24-VDC circuit are presented in figure 8.

Pulse durations of less than 35 milliseconds are not sufficient to operate the recorder; pulses longer than 50 milliseconds would throw the recorder into "cine" operation, i.e., 10 frames per second. It was essential that a timer relay consistently accurate in providing a 35- to 50-millisecond pulse over long periods of operation be incorporated in the pulse generator. The timer relay used in the present system was an Industrial Timer, Series PAF-1S (figs. 2C and 5) panel-mount interval timer. This particular model is a clutch operated, automatic reset timer relay operating on 110 VAC, 60 cycles, with a maximum time cycle of 1 second in 1/60-second increments. Wiring details of this timer relay are presented in figures 2A and 2C and table 1.



Note: All resistors 1/2 watt

Figure 6.--*Schematic diagram of the uni-junction transistor (UJT) circuit. Relay is in nonphotographing position.*



Note: All resistors 1/2 watt

Figure 7.--*Schematic diagram of the 20 VDC supply for the UJT circuit.*

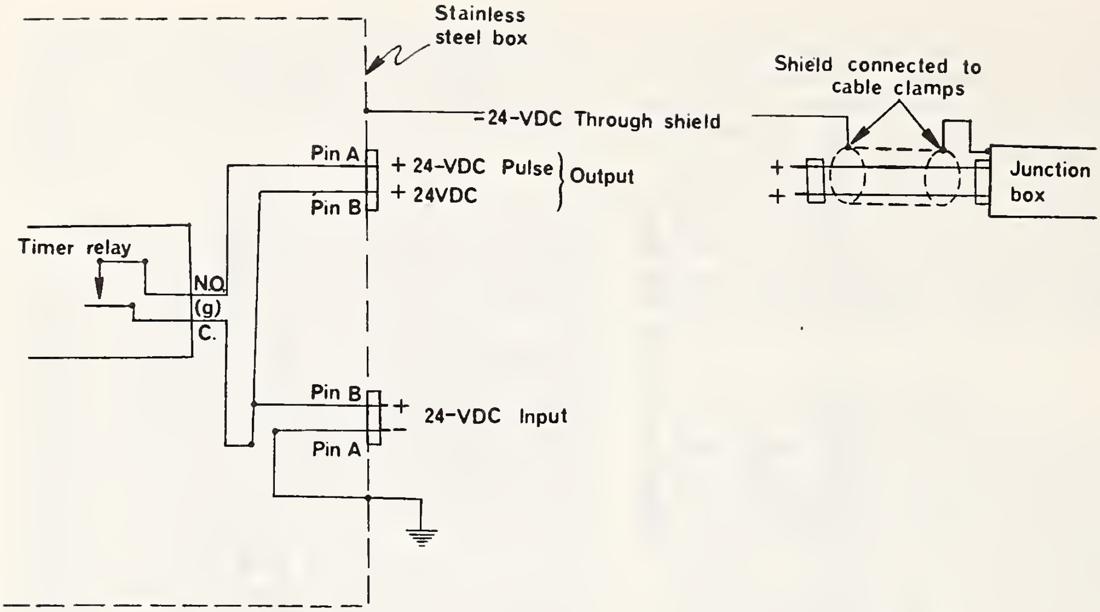


Figure 8.--*Wiring details of 24-VDC circuit.*

Frame Counter

A resetable panel-mounted counter installed on the pulse generator box and connected to the timer relay terminals L2 and CL2 (see figs. 2C and 5 and table 1) registered the number of frames exposed by the camera. The counter operates from the 110 VAC pulse that the timer relay receives from either the TDR or the UJT circuit. Each pulse is equivalent to a single-frame exposure by the camera.

Stability

The pulse generator does not appear to be temperature sensitive. Time between pulses as regulated by the 10 K variable resistor was constant for any one setting and was not affected when tested under refrigeration, at room temperature, and under variable field temperatures. This unit has been pulsed over 21,000 times during a 4-day period in an actual lumber recovery study without failure.

Junction Box

Electrical interconnection of the pulse generator, camera, and strobe unit are centralized through a 2- by 2- by 4-inch junction box (fig. 2A). This junction box also provides 110-VAC power for the camera-drive motor. To prevent misconnecting of the synchronization line at the box, a three-prong amphenol plug was installed (one prong unused) for this line. Wiring details of the junction box are presented in table 2.

APPLICATION

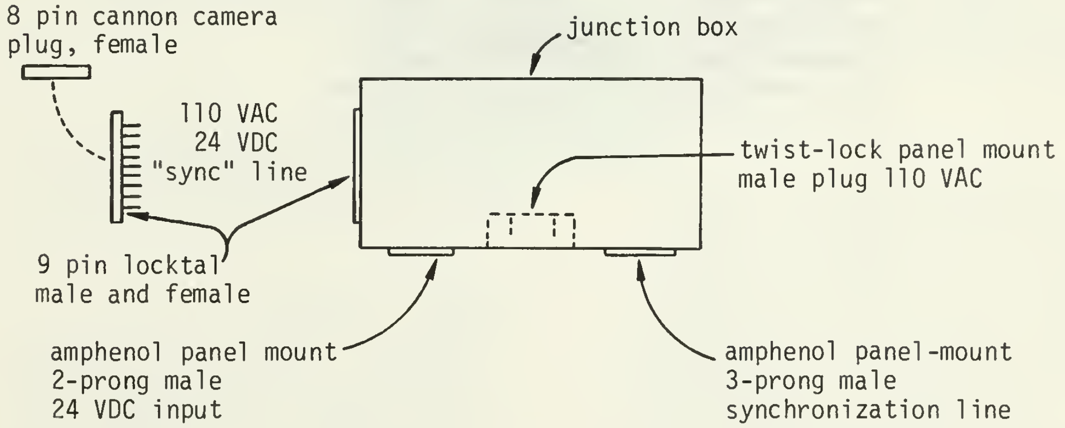
The photoelectric triggering mechanism has been successfully used with a Traid Automax G-3 pulse-operated camera. This cine pulse camera is similar to the G-1 model described by Smith (see footnote 2), differing only in having a 110-VAC drive motor instead of a 24-VDC motor. When fitted with a wide angle (25- to 35-mm) Kinoptik lens, board lengths

up to 28 feet can be obliquely photographed with good resolution. Electrical connections between junction box and the camera are shown in table 2. The power needed to operate the shutter, relays, and takeup motor in the camera is supplied by a 24 VDC source furnished with the camera.

Boards are illuminated by strobe lights which are synchronized with the shutter of the camera. A "sync" line connects the camera and strobe power pack through the junction box (see fig. 2A and table 2). Each pulse received by the camera from the pulse generator trips both the camera shutter and the strobe unit. Any satisfactory strobe unit can be used with the photoelectric triggering mechanism, since the only connection to the system occurs at the junction box via the synchronization line. A Balcar electronic flash, model T-1005, with two heads was used in the present photographic system. At 300 watt-seconds this unit recycles in 0.7 seconds. A constant source of light (e.g., photofloods) may also be used, in which case there is no electrical connection to the recorder.

Table 2.--Wiring chart for camera plug and junction box plugs

9 pin locktal pin number	2-prong (24 VDC line)	3-prong ("sync" line)	Twist lock (110 VAC)	Camera plug 8 pin cannon pin (wire)
1 chassis ground				A (white)
2			x	E (black)
3	+24 VDC pulse B			B (orange)
4	+24 VDC constant A			H (green)
5			x	F (red)
6				D (not used)
7		A		G (blue)
8		B		C (brown)
9 (not used)		C (not used)		



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